# Applications for mini VTOL UAV for law enforcement

Douglas Murphy[a], James Cycon[b]

[a]Space and Naval Warfare Systems Center, San Diego, [b]Sikorsky Aircraft Corporation

## ABSTRACT

Remotely operated vehicle systems, ground and air, have great potential for supporting law enforcement operations. These systems, with their onboard sensors, can assist in collecting evidence, performing long term surveillance or in assessing hazardous situations prior to committing personnel. Remote ground vehicles are presently used by many police departments for ordnance clearing missions. Unmanned ground vehicles (UGVs) typically offer long endurance, and are intuitive to operate but can be severely limited in where they can go by terrain and obstacles. Unmanned air vehicles (UAVs) have three-dimensional mobility but have landing and takeoff restrictions, mission time limitations, and typically are demanding to operate.

A new capability has been demonstrated for the U.S. military that shows great promise for aiding police agencies. This concept uses a shrouded rotor, vertical take-off and landing (VTOL), unmanned air vehicle to provide mobility to sensors and other payloads. This system can either perform surveillance from the air or travel to a remote location and land to position onboard sensors to perform long term surveillance from the ground. This mobility platform concept can also be used to position packages (e.g., communications repeaters) or deliver and deploy non-lethal agents.

This paper presents the concept of a small, UAV, VTOL, sensor mobility system for support of law enforcement operations. It then discusses operational feasibility and briefly reviews demonstrations of surveillance and sensor placement operations in military urban terrain scenarios performed by the Space and Naval Warfare (SPAWAR) Systems Center San Diego (SSC-SD) and Sikorsky Aircraft with their full size Cypher UAV. We then discuss the practicality of reducing the size of this capability to a system small enough to be transported in standard police vehicles and which can easily be operated by law enforcement personnel.

**Keywords:** Sensors, UAV, VTOL, Law Enforcement, UGV, robot, Cypher, Sikorsky, SPAWAR

## 1. INTRODUCTION

Expanding threats (e.g., terrorism, weapons of mass destruction), increases in crime, and budget pressure are forcing law enforcement agencies (LEAs) to look to technological capabilities to more effectively perform their missions. The concept of having a small, very maneuverable, unmanned air vehicle (UAV) that can be operated by officers in the field to provide overhead surveillance, remote sensing, communications relay or ultimately the "fly on the wall" surveillance capability has great appeal. This paper discusses a concept for providing this type of capability and presents data on proof of concept trials that have been conducted by the Department of Defense (DOD) on a larger version of the system.

## 2. BACKGROUND

When faced with potentially dangerous situations police officers need as much information on the situation as possible before committing to a course of action, as do military personnel. Given this type of information law enforcement personnel can plan their operations to be as effective and safe as possible. Typically such information is gathered by the personnel on the scene. Moving field personnel into unknown or high threat situations can expose them to undue hazards. If available and the situation warrants, aircraft or helicopter aerial surveillance can be called in to provide additional assistance. Availability of aircraft is typically limited to large organizations, the numbers of aircraft available are limited, they require dedicated pilots, and are costly to operate. Law enforcement agencies (LEAs) are beginning to look at unmanned systems to perform reconnaissance and surveillance. The idea of a small, low cost, unmanned, vertical take-off and landing air vehicle is particularly attractive for these types of applications. Such a system could be carried to the operational site in a police patrol car or pickup and be used to perform reconnaissance of the operational area using video or thermal cameras. A small VTOL system would provide officers with the ability to see over and beyond large structures such as buildings without being hampered by ground terrain. The system could be utilized to emplace sensors, or communications repeaters for enhanced communications coverage. It could also maintain an overwatch position to aid in command and control, delivery of non-lethal agents, carry chemical sensors to survey suspected drug manufacturing sites or land in hazardous or difficult to reach

| Report Documentation Page | | | *Form Approved* *OMB No. 0704-0188* |
|---|---|---|---|
| Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. | | | |
| 1. REPORT DATE<br>**NOV 1998** | 2. REPORT TYPE<br>**N/A** | | 3. DATES COVERED<br>**-** |
| 4. TITLE AND SUBTITLE<br>**Applications for Mini VTOL UAV for Law Enforcement** | | | 5a. CONTRACT NUMBER<br>5b. GRANT NUMBER<br>5c. PROGRAM ELEMENT NUMBER |
| 6. AUTHOR(S)<br>**Douglas /Murphy; James /Cycon** | | | 5d. PROJECT NUMBER<br>5e. TASK NUMBER<br>5f. WORK UNIT NUMBER |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br>**Space and Naval Warfare Systems Center San Diego, CA 92152-7383** | | | 8. PERFORMING ORGANIZATION REPORT NUMBER |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | | | 10. SPONSOR/MONITOR'S ACRONYM(S)<br>11. SPONSOR/MONITOR'S REPORT NUMBER(S) |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT<br>**Approved for public release, distribution unlimited** | | | |
| 13. SUPPLEMENTARY NOTES | | | |
| 14. ABSTRACT | | | |
| 15. SUBJECT TERMS | | | |

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT<br>**unclassified** | b. ABSTRACT<br>**unclassified** | c. THIS PAGE<br>**unclassified** | **UU** | **9** | |

locations to provide long term surveillance. The cost of operating this type of system should be much less than the cost of operating a helicopter, potentially providing greater availability to smaller law enforcement agencies.

Recent work funded by the DOD has demonstrated this type of capability for military applications using a large technology demonstrator. Technology advances in the areas of miniaturized flight controls, sensors, communications and advanced materials support the reduction in size and cost of the system demonstrated to one that should be of interest to LEAs.

## 3. CONCEPT

The proposed system would consist of a small (three feet or less in diameter) VTOL shrouded rotor UAV. This platform size is small enough to be carried in available police vehicles, e.g., cars or pickup trucks yet large enough to provide reasonable levels of performance. The size also implies low weight which will ease handling in the field. This platform would provide three-dimensional mobility to a variety of interchangeable mission packages. The shrouded rotor platform provides a more compact design than an open blade helicopter configuration. System safety is improved due to the shrouded blades. At the same time this design concept provides improved hover and precision maneuver characteristics. The flight control of the system is supervisory, i.e., the operator directs the motion of the platform, but does not fly it. Supervisory control allows the system to be operated by field personnel as a collateral duty and does not require a dedicated operator / pilot. The onboard flight control system takes care of maintaining platform stability and coordinating the controls to respond to operator direction. The aircraft is envisioned to be a mobility platform for multiple mission modules. The primary module is for reconnaissance and surveillance. Both daylight and thermal sensors are included. The thermal sensor enhances detection of people and vehicles in shadowed areas, in foliage, in smoke, as well as at night. A network based communications and control architecture will be utilized[1]. This architecture allows information to be accessed by other personnel requiring it and also simplifies integration supporting a plug and play approach for multiple mission packages. The radio frequency (RF) network also allows passing of control between operators and integration of information at the command control station.

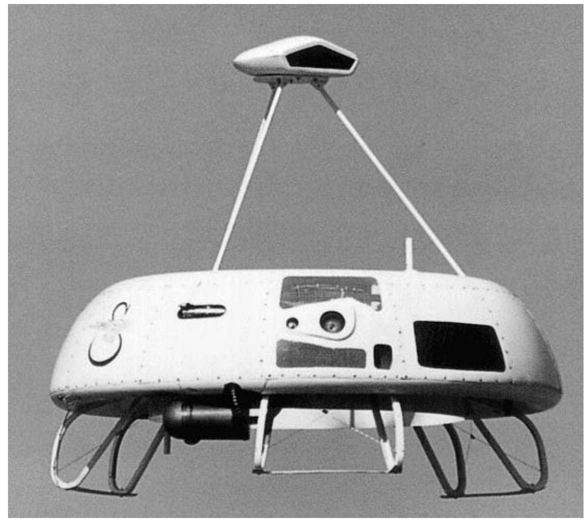
The system must be designed to assist operational personnel and must not detract or encumber them during prosecution of their mission. The control unit for the system is based on body-worn computer and head mounted display technology. These systems are currently being developed in DOD and can be incorporated into the officer's bullet proof vest. Operator input to the body worn systems is through arm mounted key pads, small joy sticks, small computer mouse devices or voice input.

## 4. SUPPORTING TECHNOLOGY AND EXPERIENCE

In fiscal year 1992 SSC-SD under U.S. Army sponsorship initiated a program to investigate the feasibility of using small, vertical take-off and landing unmanned aircraft to position remote surveillance sensors in the battlefield[2,3] (Figure 1). The objective of the concept was to enhance the capability of Military Police (MP) Squads, in tactical security missions, to cover large areas of the rear area of a battle field. The system concept was originally called the Air Mobile Ground Security and Surveillance System (AMGSSS) and then the Multi-Purpose Security and Surveillance Mission Platform (MSSMP). The MSSMP operational scenario was based on a squad of three MPs deploying with a High Mobility Multi Wheeled Vehicle HMMWV towing a trailer holding three air mobility platforms. When the squad reached a central location in their area of responsibility they would launch one or all of the air mobility platforms to locations at which they desired to perform long term ground surveillance. The air mobility platform was a shrouded rotor, VTOL UAV with a sensor suite mounted on top of it. The platform would fly to target location where it would autonomously land and then conduct long term surveillance with its on board sensors. To reduce communication power and time of communication the sensor data was processed onboard the platform by automatic motion detection software. This allowed the system operator to monitor several systems at once since information was broadcast only when something of interest was occurring. At the end of the mission or when surveillance was required in another location the system would be commanded to restart, takeoff and go to the new location or return to its launch point.

1. MSSMP Operational Concept

The advantage of this type system is that it allowed remote sensors to be quickly deployed to a remote site without the concern of driving over the intervening terrain that a ground vehicle would have. One squad could quickly deploy and control three remote sensor systems to an operating radius of ten kilometers. At the start of the MSSMP program a Broad Agency Announcement was advertised to determine the state of the art in VTOL UAVs. Sikorsky Aircraft Corporation's Cypher UAV was selected as the best system available to demonstrate the MSSMP mission. A program was initiated FY1993 to demonstrate the feasibility of the MSSMP concept by incorporating a SSC-SD developed mission sensor package (motion detection system, sensor control and display unit) into a tripod mounted above the Cypher vehicle (Figure 2). The combining of SSC-SD sensor package and Sikorsky Cypher UAV yielded a mobile remote sentry that could perform reconnaissance, surveillance and target accusation (RSTA) from the air or land at a remote location to perform ground RSTA. This capability was demonstrated during nine operational experiments conducted over the past four years.

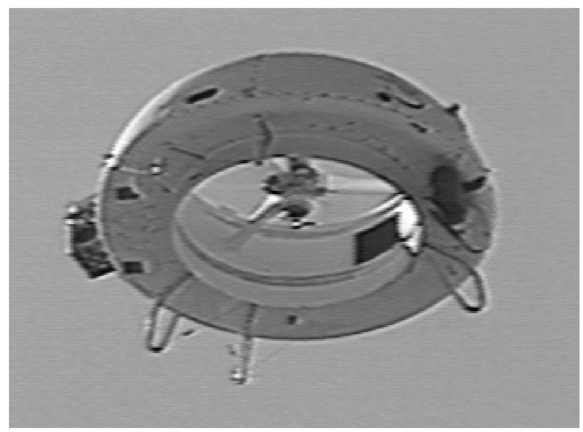


2. Cypher in MSSMP Configuration

## Cypher Description

The Cypher aircraft (Figure 3), concept is an innovative approach to UAVs because it is the first and only ducted configuration using rigid coaxial rotors coupled with an external shroud to control and stabilize the aircraft[4, 5, 6, 7, 8]. The two coaxial counter-rotating rotors balance torque, plus provide aircraft lift and all directional control. The shroud is multi-functional: it supports the rotors, produces a portion of the lift, and contains propulsion, avionics, fuel, payload, and other flight-related hardware. This configuration also enhances vehicle and operator safety for operations in confined areas by protecting the rotor from tip strikes.

The present Cypher technology demonstrator (Cypher-TD) is six feet in diameter, two feet high, and was designed to carry a 25 to 50 lb. sensor payload for two to three hours, depending on operational conditions. The key attributes of the Cypher UAV are summarized in the Table 1.



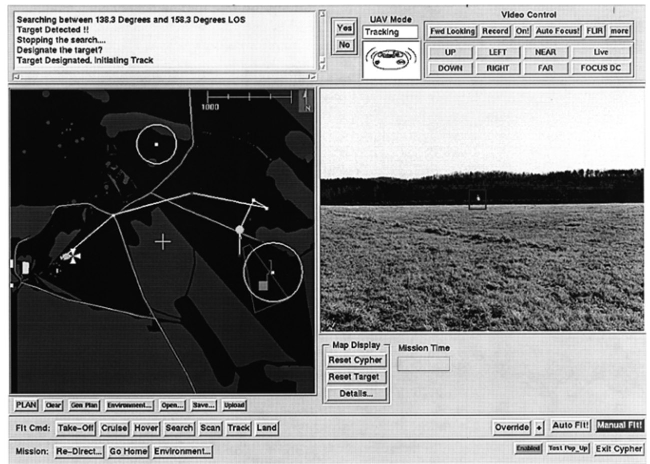
3. Cypher-TD

**Table 1, Cypher-TD Characteristics**

| Characteristic | Value | Characteristic | Value |
|---|---|---|---|
| Body Diameter | 6.5 ft | Altitude (max) | 8,000 ft |
| Height | 2.0 ft | Speed (max) | 60 mph |
| Rotor Diameter | 4.0 ft | Endurance (max) | 2-3 hours |
| Nominal Weight | 264 lb. | Max Range | 90-125 km depending on model |
| Maximum Take-off Weight | 300 lb. To 340 lb. (depending on engine) | Payloads | EO, FLIR, small radars, chemical detectors and magnetometers, radio relay, and non-lethal payloads |
| Payload Weight | 25 to 50 lb. | Transportability | HMMWV or sport utility vehicle with standard trailer. |

One of the major objectives of the Cypher-TD program was to develop a user friendly VTOL UAV that could be easily controlled with simple operator commands. This was made possible by a sophisticated flight control system and an operator

friendly graphical user interface called the Sikorsky System Manager. Presently the entire Cypher UAV mission can be planned, implemented, and monitored from the System Manager display (Figure 4).




4. Cypher Control Panel

The System Manager display is split into two portions. The left side displays a digital map of the area of interest, and the right displays the payload sensor output. To plan a mission the operator selects enroute/destination waypoints or areas to be searched using a mouse. Route planning software then plans a safe route to selected the waypoints or search areas. The proposed route is displayed to the operator for acceptance. Soft buttons for control of aircraft functions, such as; auto takeoff, cruise, search, etc., are also displayed on the bottom portion of the System Manager screen. The right side of the System Manager display shows real-time data from the onboard sensor. This data includes full video or FLIR imagery. Data from the FLIR can be analyzed by an Automatic Target Recognition (ATR) system to detect targets and provides target location information back to the System Manager. Aircraft and target position along with track history are displayed on the digital map[9, 10].

The Cypher aircraft's advanced flight control system software and integrated avionics subsystems interface with the System Manager such that mission execution is highly automated requiring little or no operator intervention. Table 2 lists a few of the automated capabilities the Cypher-TD has demonstrated during the program.

**Table 2, Demonstrated Automated Flight Capability**

| Capability | Comments |
|---|---|
| Automatic takeoff & landing | Remote landings and takeoffs at distant locations |
| Automatic return home | uplink loss engages automatic return home sequence |
| Waypoint navigation | Includes enroute and destination points |
| Sloped landings | 15 degree slope achieved to date |
| Automatic target tracking | Includes auto search and scan features |
| Landings/takeoffs from unprepared surfaces | Routinely performed on grass, sand, rocky terran, etc. |
| Precision payload placement | Placement at predetermined waypoints |
| Confined area operations | Landed on roof of multi-story building |

The Cypher-TD aircraft has been designed to accommodate a variety of sensors, not only Electro Optic (EO) and Forward Looking InfraRed (FLIR), but also magnetometers or chemical detectors[11]. The aircraft is easily reconfigured with different sensors depending on the mission, quality of the image desired, time of day, and range of use. The sensor can be mounted on a single-axis mount for elevation motion with azimuthal orientation being accomplished by rotating the air vehicle about its center of rotation. To control the sensor payload, the operator clicks buttons on the system manager display changing sensor elevation and azimuth.

The following Payload Sensors have been flown on the Cypher aircraft:

- FLIR (both airframe and pod mounted)
- Video (both airframe and pod mounted)
- Cesium Magnetometer
- Laser range finder
- Chemical canisters
- EMI sensor

## SSC-SD Mission Package

SSC-SD developed the sensor payload that flew on the Cypher to support remote reconnaissance, surveillance and target acquisition (RSTA)[12]. The sensors, and their control electronics were mounted in a housing on a tripod located on the top of the Cypher. The height of the tripod was set so that the sensors would be at human eye height when the Cypher was on the ground. The remainder of the electronics supporting the RSTA package, communications and date processors were located in the Cypher body.

The RSTA sensor payload was mounted on a pan-and-tilt unit, and includes a visible light video camera, infrared camera (FLIR), and laser range finder. In addition, a serial port is provided to interface to an optional portable acoustic sensor. To minimize radio traffic, most sensor processing is performed by the remote payload. Acoustic and visual motion detection is used to detect, identify, and locate targets of interest. Preprogrammed responses are activated upon detection and may consist of only a simple alert to the operator, or may also include the automatic transfer of a static image, laser range value or an image stream.

For the prototype unit, the operator's control display station is a laptop computer running a graphical Windows program. Commands to the remote sensors are initiated using the laptop's keyboard and pointing device, and returned data and images are displayed on the laptop's color display. The communications approach initially explored for the MSSMP utilized military SINCGARS radios and prototype PCMCIA Tactical Communication Interface Modules (TCIMs) from Magnavox. (SINCGARS is a frequency hopping or single channel VHF-FM radio that operates in the 30 - 88 Mhz frequency range. It provided only 16kbps throughput, and takes several hundred msec to switch between transmit and receive modes.) Field tests conducted in 1995 showed that SINCGARS radios were not an effective means of communicating "high bandwidth" data like imagery/video. MSSMP therefore moved to COTS Arlan 640 Ethernet bridges as the basis for communications between all remote payload subsystems and the control/display station.

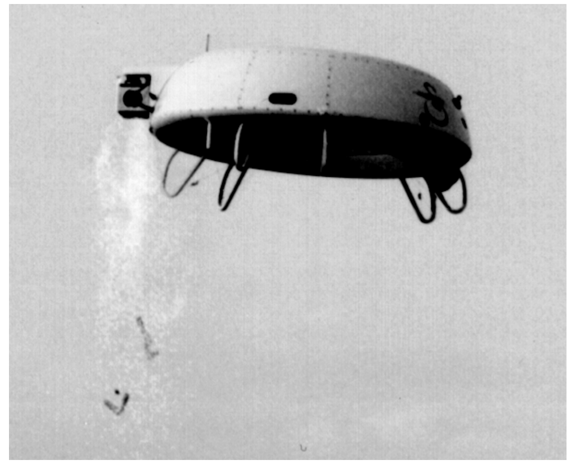
## Demonstrated Operational Capabilities

SSC-SD and Sikorsky Aircraft have conducted many demonstrations of the MSSMP concept performing a multitude of missions. At the McKenna Military Operations in Urban Terrain (MOUT) training site in Ft. Benning, Cypher in the MSSMP configuration flew up and down city streets in very close proximity to buildings (Figure 5); scouted second story windows, and successfully landed on the flat roof of a multi-story building to act as a remote sentry (Figure 6). The roof was approximately 20 ft. by 20 ft. The automatic landing was easily completed within 1 ft. of the center of the roof. Video surveillance was conducted from the roof using the top mounted sensor pod. The Cypher UAV flights at the Ft. Benning MOUT facility clearly demonstrated the Cypher UAV's potential to perform a variety of missions in the urban environment[2].

5. Cypher Operations in Confined Areas

6. Remote Landing on a Roof-Top

A counter-drug operational demonstration was conducted for the US Army Military Police School, Ft. McClellan, Alabama in which the MSSMP system was deployed to a remote site simulating an airfield in a wooded area that was not accessible to law enforcement personnel. The system, once in place, surveilled the area to document a simulated drug transaction.



7. Cypher UAV dispensing smoke

Additionally a Cypher UAV non-lethal payload delivery experiment was conducted at the Ft. Benning MOUT facility. The main goal of the experiment was to demonstrate that Army operators, with only minimum training (approx. 1 hour), could plan and conduct a mission using the Cypher UAV to perform precision dropping of different types of non-lethal payloads. During the experiment the Cypher UAV delivered smoke canisters (Figure 7), steel spikes for destroying tires, and propaganda leaflets, all with incredible precision. All flights were planned and executed by Army MPs. This was the first time the Cypher UAV was fully operated by non-Sikorsky personnel. Each mission only required one MP for planning and execution. The two MPs alternated roles between operator and observer (Figure 8). This operation is directly relevant to civilian police missions.

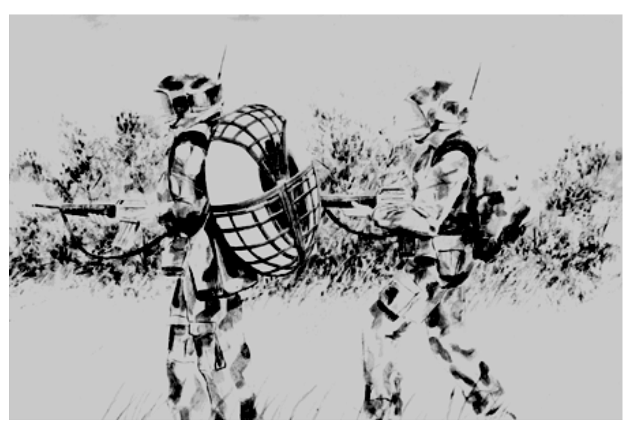
Additional experiments included the Autonomous Scout Rotorcraft Testbed (ASRT) program where Cypher autonomously searched for and tracked man-sized targets with no operator input. The Department of Energy used Cypher, carrying magnetometers, to search and find underground structures and tunnels in Nevada. With these demonstrations and five years of flight testing the Cypher technology demonstrator aircraft has proven its value as a tactical reconnaissance asset and the MSSMP program has shown the feasibility of using this type of platform for support of Military Police operations.

9. MPs Planning Mission

## Design Scalability

## Air Platform

The Cypher aircraft can be scaled up or down to meet specific mission requirements. Presently Sikorsky has designed a MiniCypher which is a man-portable version of the Cypher UAV (Figure 9). MiniCypher can be carried on the back of a person and operated through a portable ground station or body-worn computer with a helmet-mounted display. As with the present Cypher UAV, MiniCypher does not require a highly trained pilot; it is autonomous in all of its flight modes and only requires mission-oriented directives from the operator.



9. MiniCypher concept

The MiniCypher is 36” in diameter, 8” in height, and weighs 30 lbs. empty. Its useful load is 20 lbs., which is divided between fuel and payload, for a takeoff weight of 50 lbs. It shares the shrouded coaxial rotor configuration of the Cypher UAV, ensuring relatively safe operation in close proximity to personnel buildings, trees, and other obstacles. MiniCypher

can land remotely on unprepared terrain and can take off and land in confined areas as small as 3 meters square. The projected characteristics of the MiniCypher system are summarized in Table 3.

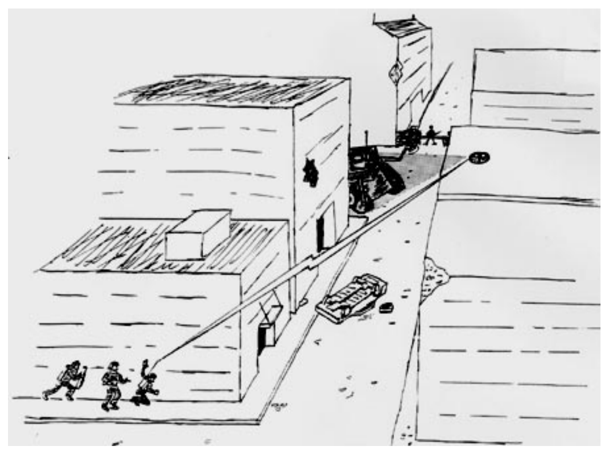
**Table 3, MiniCypher Characteristics**

| Characteristic | Value | Characteristic | Value |
|---|---|---|---|
| Body Diameter | 3 ft | Altitude (max) | 5000 ft |
| Height | 0.66 ft | Speed (max) | 60 mph |
| Rotor Diameter | 2 ft | Endurance (max) | 1-2 hours |
| Nominal Weight | 30 lb. | Max Range | 5 km |
| Maximum Take-off Weight | 50 lb. | Payloads | EO, FLIR, small radars, chemical detectors and magnetometers, radio relay, and non-lethal payloads |
| Payload Weight | 20 lb. | Transportability | Car, or Pickup Truck |

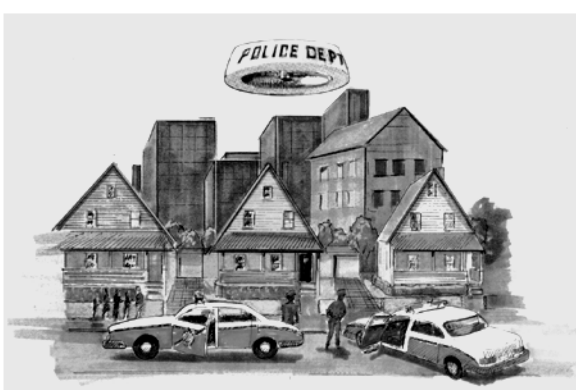
Like Cypher, MiniCypher was designed to carry a variety of payloads, depending on the needs of the mission. Sensors such as video cameras and FLIRs are mounted inside the fuselage on an elevation gimbal; azimuth control is achieved by yawing the aircraft in the desired direction. Since MiniCypher is aerodynamically symmetrical, a 360 degree panoramic sweep is easily accomplished without interrupting forward flight. Carrying a 10 lb. payload the MiniCypher can travel a distance of 5 km, loiter on station for one hour, and return to the launch point without refueling. Imagery from the sensors is transmitted back to the operator and displayed in real time.

## Potential applications

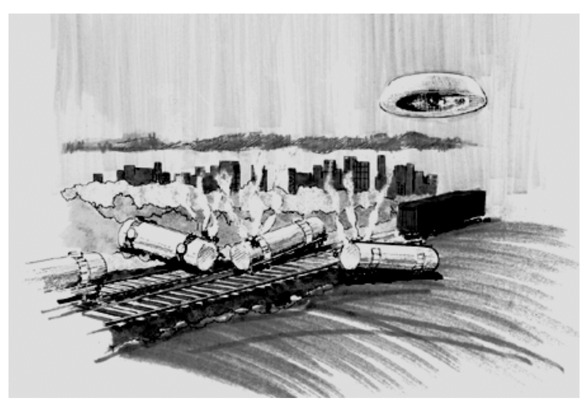
The MiniCypher UAV enhances situational awareness and extends law enforcement reach around buildings, terrain, and other obstacles (Figure 10). Reconnaissance, surveillance, and target acquisition (RSTA) is performed without exposing a human point man to danger; range finding and target designation allow close coordination with supporting air and ground assets while minimizing fratricide and collateral damage (Figure 11). MiniCypher can quickly and precisely place breaching charges against walls or atop roofs to force entry to brick or concrete buildings. MiniCypher can enhance communications effectiveness by carrying aloft a relay payload in areas where buildings obstruct line-of-sight communications links. Smoke and tear gas can be delivered with precision. MiniCypher can place a full range of Cypher UAV capability directly into the hands of law enforcement officers. Additionally MiniCypher can be used in hazardous situations to monitor toxic spills or radiation (Figure 12).



10. Provide Situational Awareness




11. MiniCypher supports Law Enforcement



12. Hazardous Spill Monitoring

Other potential missions and the sensors, detection devices, and communications hardware are shown in the table 4. Clearly,

**Table 4**

| Missions | Sensor/ Payload Type | Capabilities | Benefits |
|---|---|---|---|
| Border Surveillance | • Electro-Optic (EO)<br>• Forward-Looking Infrared (FLIR) | • Autonomous, pre-programmed navigation<br>• Near-real time imagery<br>• Object identification<br>• Person or Vehicle Tracking | • Force multiplier.<br>• Lower cost per flight hour than manned helicopter<br>• More capable than ground vehicle |
| Traffic Surveillance | • EO<br>• FLIR | • Near-real time imagery | • Force multiplier<br>• Lower cost per flight hour than manned helicopter |
| Crowd Dispersion, Communication / Riot Control | • EO<br>• FLIR<br>• Loud speaker for voice transmission<br>• Acoustic Sensor (Microphone) | • Navigate among buildings<br>• Provide near-real time information<br>• Dispense non-lethal agents | • Force multiplier<br>• Eliminate risk of human life |
| Search and Rescue Support | • EO<br>• FLIR<br>• Rescue or life-support equipment<br>• Loud speaker for voice transmission | • Systematic area search<br>• Person detection and tracking<br>• Transportation of rescue and life-support equipment | • Search small areas otherwise not accessible by manned aircraft or ground vehicle |
| Suspect or Vehicle and Tracking | • EO<br>• FLIR | • Systematic area search<br>• Person detection and tracking<br>• Vehicle, License Plate Identification | • Search small areas otherwise not accessible by manned aircraft or ground vehicle<br>• Lower cost per flight hour than manned helicopter |
| Neighborhood Patrol | • EO<br>• FLIR<br>• Loud speaker for voice transmission<br>• Acoustic Sensor | • Systematic patrolling<br>• Near-real time imagery | • Force multiplier<br>• Cypher is easily seen |
| Speed Trap Support | • X-band radar emitter/receiver<br>• Ku-Band radar emitter/receiver<br>• EO | • Autonomous or remotely-piloted flight to position<br>• Autonomous or remotely-piloted radar operation<br>• Near-real time imagery of vehicle<br>• Vehicle tracking (pursuit support) | • Force multiplier<br>• Not easily seen<br>• Lower cost per flight hour than manned fixed wing aircraft |
| Metal Object Search | • EO<br>• FLIR<br>• Magnetometer | • Systematic area search<br>• Locate weapons or metal objects | • Otherwise time consuming<br>• Force multiplication |
| Chemical Biological Agent Detection | • Infrared -based detection sensor | • Re-locatable, remote sensing<br>• Determine concentration level<br>• Survey area of interest | • Eliminate risk of human life |

MiniCypher is a versatile platform providing a single, cost-effective solution to a wide variety of law enforcement missions.

## 5. TECHNOLOGY SUPPORTING THE CONCEPT

The military and commercial electronics markets are driving down the size and cost of the sensors and subsystems required for the proposed system. Cooled FLIRS are available that weigh less than six pounds. Un-cooled FLIRS are available in the two to three pound range. Black and white and color video cameras with zoom lenses are available weighing less than three pounds. For the short ranges that these systems would be deployed many RF modems and are available with good bandwidth and in small and low weight packages to provide local area digital communications. Several manufacturers have come out with small integrated inertial measurement, GPS units. The DOD has several development programs underway which are developing the body-worn computer and display technology. As these programs mature and these systems begin to appear as operational capabilities the computer systems will be available in the commercial market at reasonable cost.

## 6. TECHNOLOGY CHALLENGES

Several required improvements were uncovered during the MSSMP demonstrations. The most significant is the requirement to quiet the system. The problem was primarily caused by the engine exhaust noise. This may be even more of a problem for a smaller system depending on small two-cycle engines. High energy density batteries and high efficiency electric motors may help with this problem. The other challenge will be to produce an integrated system that demonstrates significant capability to the law enforcement community such that the cost benefit of the system is obvious. As the cost of the subsystem technologies come down the cost utility will go up.

## 7. CONCLUSIONS

Experience gained from Cypher UAV demonstrations and the MSSMP trials supports the operational feasibility of proposed system concept. Small VTOL UAVs can be used in urban environments and open ground environments to perform visual surveillance, gather sensor data to detect and locate specific signatures and deliver packages. The current state of the art in UAV design and subsystems supports development of the proposed system for use by law enforcement agencies. This type of system can greatly enhance the capabilities of police departments of all sizes.

## 8. REFERENCES


1. Gage, D.W., W.D. Bryan, and H.G. Nguyen, "Internetting Tactical Security Sensor Systems," SPIE *Proceedings. 3393: Digitization of the Battlespace*, Orlando, FL, 15-17 April 1998.**

2. Murphy, D.W., J.P. Bott, W.D. Bryan, J.L. Coleman, D.W. Gage, H.G. Nguyen, and M.P. Cheatham, "MSSMP: No Place to Hide," *Proceedings AUVSI'97*, Baltimore, MD, 3-6 June, 1997, pp. 281-290.**

3. Murphy D. and J. Bott, "On the Lookout: The Air Mobile Ground Security and Surveillance System (AMGSSS) Has Arrived," *Unmanned Systems*, Vol. 13, No. 4, Fall 1995, pp 22-27.**

4. Cycon, J.P., "Decoding The Cypher UAV", Vertiflite, Nov / Dec 1990

5. Cycon, J.P., "Sikorsky Aircraft UAV Program", Vertiflite, May / June 1992, pp. 26-30

6. Moore, S.F., and J.P. Cycon, "Effectiveness of Shrouded Rotor UAVs in Support of CLOSE Range Missions", *Proceedings Association for Unmanned Vehicle Systems 19th Annual Technical Symposium* , Washington D.C., June 22-24, 1992

7. Cycon, J.P., B. Wayner, and C.W. Withers, "Beyond Defense: Commercialization of UAV's", *Unmanned Systems Magazine*, Vol. 11, Number 3, Spring 1993, pp. 38-40

8. Copper, D.E., and J.P. Cycon, "Sikorsky Aircraft UAV Development", Proceedings *Nineteenth European Rotorcraft Form*, Cernobbio, Italy, September 14-16, 1993

9. Cycon, J.P, and C.A. Thornberg,. "Sikorsky Aircraft's Unmanned Aerial Vehicle, Cypher System Description and Program Accomplishments", *American Helicopter Society 51rd Annual Form*, Fort Worth Texas, May 9-11, 1995

10. Cycon, J.P., and D.M. Walsh., "Autonomous Flight of the Cypher UAV", *Proceedings American Helicopter Society 53rd Annual Form*, Virginia Beach, Virginia, April 29- May 1, 1997,

11. Sandness, G.A., T.L. Stewart, D. St. Pierre, and J.P. Cycon, "UAV Sensor Platform", JEEG, Vol 2, issue 2, September 1997, pp. 79-88

12. Murphy, D.W., J.P. Bott, J.P. Cycon, W.D. Bryan, J.L. Coleman, D.W. Gage, W.C. Marsh, B.F. Martin, H.G. Nguyen, and R. Schneider, "Air-Mobile Ground Security and Surveillance System (AMGSSS) Project Summary Report," *Technical Document 2914*, NCCOSC RDT&E Division, San Diego, CA; September 1996 (AD-A317618).


** Papers can be obtained from web site http//www.nosc.mil/robots